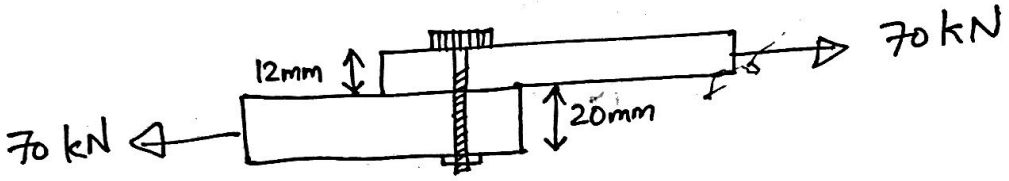
(91) Design a ~~lap joint~~ bolted connection between 2 plates of thickness 12mm & 20mm each, subjected to a load 70 kN. Use M16 bolts of grade 4.6, and Fe 410 grade plates.

Ans:



Design of bolts:

(i) Design shear capacity of bolt (Pg 75 – IS 800 cl. 10.3.3)

$$V_{dsb} = \frac{f_{ub}\,(n_n A_{nb} + n_s A_{sb})}{\sqrt{3}\ \gamma_{mb}}$$

where $f_{ub} = 400\ N/mm^2$ (∵ 4.6 grade bolts)

$\gamma_{mb} = 1.25$ (Pg 30 – Tables of IS 800)

$n_n = 1$

$n_s = 0$

$A_{nb} = 0.78\ \pi/4 \times 16^2 = 157\ mm^2$

$A_{sb} = 0$

$$\Rightarrow V_{dsb} = \frac{400(1 \times 157 + 0)}{\sqrt{3} \times 1.25} = 29006\ N$$

$$= \underline{29.01\ kN}$$

(ii) Design bearing capacity of bolt (Pg 75 – IS800 Cl. 10.3.4)

$$V_{dpb} = \frac{2.5 k_b \, d \, t \, f_u}{\gamma_{mb}}$$

where $d = 16$ mm

$t = 12$ mm (thinner plate)

$f_u = 410$ N/mm^2

k_b = smaller of $\begin{cases} e/3d_o = \frac{27}{3\times 18} = 0.50 \\ p/3d_o - 0.25 = \frac{40}{3\times 18} - 0.25 = 0.49 \\ f_{ub}/f_u = \frac{400}{410} = 0.98 \\ 1 \end{cases}$

$= 0.49$

Assume $d_o = 16 + 2 = 18$ mm (Refer Table 19 – page 73 of IS800)

$e = 1.5 d_o = 1.5 \times 18 = 27$ mm

(refer Pg 74 – Cl. 10.2.4.2 – machine cut)

$p = 2.5 d = 2.5 \times 16 = 40$ mm

(refer Pg 73 – Cl. 10.2.2 – pitch)

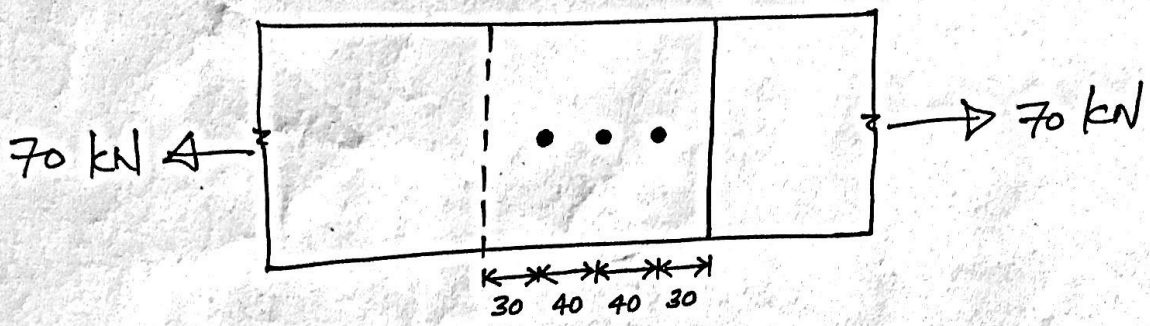
$$\Rightarrow V_{dpb} = \frac{2.5 \times 0.49 \times 16 \times 12 \times 410}{1.25}$$

$= 77146$ N $=$ **77.15 kN**

∴ Bolt value = Smaller of bolt capacities

= **29.01 kN**

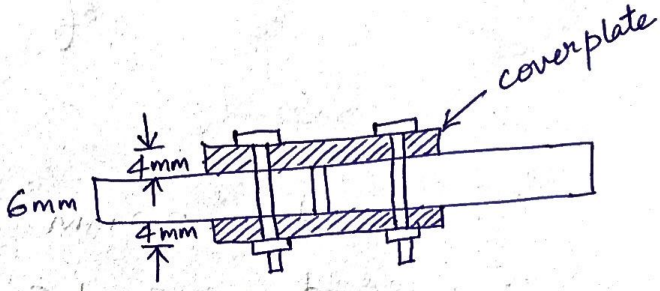
No: of bolts required $= \frac{70}{29.01} \approx$ **3 nos**



Q2

(9.) A ~~single bolted~~ double cover butt joint is used to connect two plates 6mm thick. Assuming 4.6 grade M20 bolts and 4mm thick cover plates. Plates are of grade Fe410. Design the joint, if requires to transfer a force of 100 kN.

Ans:



Shear capacity of bolt

$$V_{dsb} = \frac{f_{ub}}{\sqrt{3}} \frac{(n_n A_{nb} + n_s A_{sb})}{\gamma_{mb}}$$

where $f_{ub} = 400\ N/mm^2$ (for 4.6 grade bolts)

$\gamma_{mb} = 1.25$ (Table 5 – Pg 30)

$n_n = 1$, $n_s = 1$ } there are two shear planes each passing through thread & shank

$A_{nb} = 0.78\ \pi/4 \times 20^2 = 245\ mm^2$

$A_{sb} = \pi/4 \times 20^2 = 314\ mm^2$

$$\Rightarrow V_{dsb} = \frac{400}{\sqrt{3}} \frac{[(1 \times 314) + (1 \times 245)]}{1.25}$$

$$= 103.28\ kN$$

Bearing capacity of bolt

$$V_{dpb} = \frac{2.5\, k_b\, d\, t\, f_u}{\gamma_{mb}}$$

~~where k_b =~~

~~e =~~

where k_b = Smaller of $\begin{cases} e/3d_o \\ p/3d_o - 0.25 \\ f_{ub}/f_u \\ 1 \end{cases}$

$d = 20\ mm$

$d_o = 20 + 2 = 22\ mm$ (Pg 73 – Table 19)

$e = 1.5 d_o = 1.5 \times 22 = 33\ mm$
(Pg 74 – Cl. 10.2.4.2)

$p = 2.5d = 2.5 \times 20 = 50\ mm$
(Pg 73 – Cl. 10.2.2)

$f_{ub} = 400\ N/mm^2$

$f_u = 410\ N/mm^2$

$\Rightarrow k_b$ = Smaller of $\begin{cases} \frac{33}{3\times22} = 0.50 \\ \frac{50}{3\times22} - 0.25 = 0.51 \\ 400/410 = 0.98 \\ 1 \end{cases} = 0.50$

t = Smaller of $\begin{cases} 6\ mm \\ 4+4 = 8\ mm \end{cases} = 6\ mm$

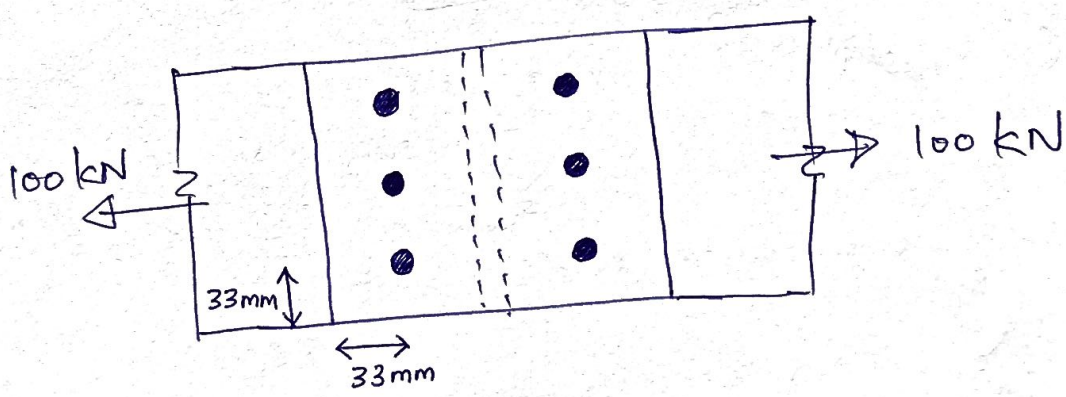
$$V_{dpb} = \frac{2.5 \times 0.5 \times 20 \times 6 \times 400}{1.25} \quad \leftarrow \text{smaller of } f_{ub} \text{ \& } f_u$$

$$= \underline{\underline{48 \text{ kN}}}$$

$\therefore$ Strength of bolt or Bolt value $= \text{Smaller of } \begin{cases} V_{dsb} \\ V_{dpb} \end{cases}$

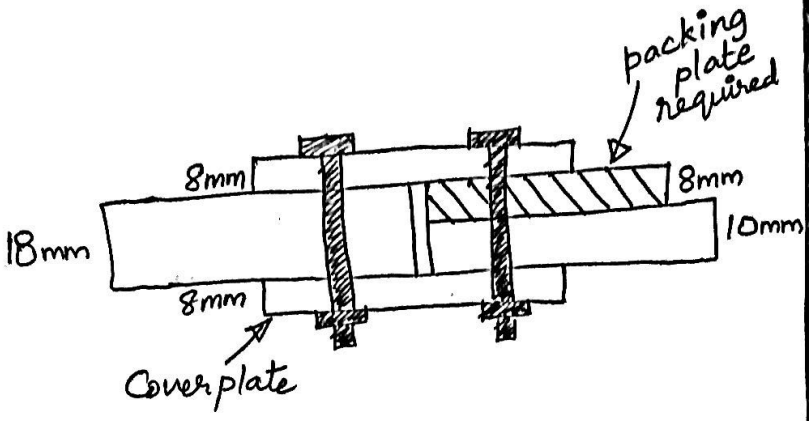
$$= \underline{\underline{48 \text{ kN}}}$$

$\therefore$ No: of bolts required on each side of the double-cover butt joint $= \frac{100}{48} \approx \underline{\underline{3 \text{ nos}}}$



(9:) Determine the design shear capacity of bolt for a joint comprising 10mm & 18mm thick plates connected by two coverplates of 8mm thick. Use M20 bolts of 4.6 grade.

Ans:



Shear capacity of bolt

$$V_{dsb} = \frac{f_{ub}}{\sqrt{3}} \frac{(n_n A_{nb} + n_s A_{sb})}{\gamma_{mb}}$$

where $f_{ub} = 400\ N/mm^2$

$\gamma_{mb} = 1.25$

$n_n = 1$ } two shearplanes, each passing through shank & thread
$n_s = 1$ }

$A_{nb} = 0.78\ \pi/4 \times 20^2 = 245\ mm^2$

$A_{sb} = \pi/4 \times 20^2 = 314\ mm^2$

$$\Rightarrow V_{dsb} = \frac{400}{\sqrt{3}} \frac{[(1\times 245) + (1\times 314)]}{1.25}$$

$$= \underline{103.28\ kN}$$

Since a packing plate of thickness exceeding 6mm is used, reduction factor (β_{pk}) is required to be multiplied.

$$\therefore \beta_{pk} = 1 - 0.0125\, t_{pkg}$$

$$= 1 - (0.0125 \times 8)$$

$$= \underline{\underline{0.90}}$$

$\therefore$ Design shear capacity of bolt

$$= V_{dsb} \times \beta_{pk}$$

$$= 103.28 \times 0.90$$

$$= \underline{\underline{92.95\ kN}}$$